CLAIMS

1. A semiconductor laser characterized by comprising:

a substrate made of InP;

an active layer including a multiquantum well structure formed above the substrate in a width of 7 to 14 μm; and

an n-type cladding layer made of InGaAsP and a p-type cladding layer made of InP which are formed above the substrate with the active layer interposed therebetween, wherein

light which oscillates only in a fundamental lateral mode to be emitted from an exit facet is optically coupled with an external single mode optical fiber.

2. The semiconductor laser according to claim 1, characterized in that the light emitted from the exit facet is optically coupled with the external single mode optical fiber without resort to lens.

3. The semiconductor laser according to claim 1, characterized in that the light emitted from the exit facet is optically coupled with the external single mode optical fiber by butt joint.

4. The semiconductor laser according to claim 1, characterized by further comprising:

a first separate confinement heterostructure (SCH) layer made of InGaAsP, which is formed between the

active layer and the n-type cladding layer; and

a second SCH layer made of InGaAsP, which is formed between the active layer and the p-type cladding layer.

5. The semiconductor laser according to claim 4, characterized in that

the first SCH layer includes a multilayer structure formed of a plurality of layers, and

the second SCH layer includes a multilayer structure formed of a plurality of layers.

6. The semiconductor laser according to claim 5, characterized in that

assuming that a refractive index of a plurality of partition layers in the active layer is ns;

that a refractive index and thickness of said plurality of layers in the first SCH layer are n1, n2, n3, ..., nN and t1, t2, t3, ..., tN, respectively, sequentially from a side closer to the active layer; and

that a refractive index and thickness of said plurality of layers in the second SCH layer are n1, n2, n3, ..., nN and t1, t2, t3, ..., tN, respectively, sequentially from the side closer to the active layer,

a relationship of the thicknesses of the layers is mutually uniform, being set in a relation of:

$t1 = t2 = t3 = , ..., = tN$,

a great and small relationship of the refractive

indexes of the layers is set so as to be smaller as going further from the active layer as shown below, including a relationship in which the refractive index ns of the active layer is highest, and a refractive index na of the n-type cladding layer is higher than a refractive index nb of the p-type cladding layer:

$$ns > n1 > n2 > n3 >, \ldots, nN > na > nb,$$ and further

a refractive index difference between mutually adjacent layers among said plurality of layers which compose the first SCH layer and second SCH layer is set to be smaller as going from the active layer to the n-type cladding layer and p-type cladding layer in a relationship of:

$$ns-n1 > n1-n2 > n2-n3 >, \ldots, > nN-nb > nN-na.$$

7. The semiconductor laser according to claim 5, characterized in that

assuming that a refractive index of a plurality of partition layers in the active layer is ns;

that a refractive index and thickness of said plurality of layers in the first SCH layer are n1, n2, n3, ..., nN and t1, t2, t3, ..., tN, respectively, sequentially from a side closer to the active layer; and

that a refractive index and thickness of said plurality of layers in the second SCH layer are n1, n2, n3, ..., nN and t1, t2, t3, ..., tN, respectively,

sequentially from a side closer to the active layer,

a great and small relationship of the refractive indexes of the layers is set so as to be smaller as going further from the active layer as shown below, including a relationship in which the refractive index ns of the active layer is highest, and a refractive index na of the n-type cladding layer is higher than a refractive index nb of the p-type cladding layer:

$ns > n1 > n2 > n3 >, \ldots, nN > na > nb$,

a refractive index difference between mutually adjacent layers among said plurality of layers which compose the first SCH layer and second SCH layer is set to be in a relationship of:

$ns-n1 = n1-n2 = n2-n3 =, \ldots, = nN-nb$ (provided that $nN-nb > nN-na$), and

a relationship of the thicknesses of the layers is set in the following relation so as to be larger as being more remote from the active layer:

$t1 < t2 < t3, \ldots, < tN$.

8. The semiconductor laser according to claim 5, characterized in that

assuming that a refractive index of a plurality of partition layers in the active layer is ns;

that a refractive index and thickness of said plurality of layers in the first SCH layer are n1, n2, n3, ..., nN and t1, t2, t3, ..., tN, respectively, sequentially from a side closer to the active layer;

and

that a refractive index and thickness of said plurality of layers in the second SCH layer are n1, n2, n3, ..., nN and t1, t2, t3, ..., tN, respectively, sequentially from the side closer to the active layer,

a great and small relationship of the refractive indexes of the layers is set so as to be smaller as going further from the active layer as shown below, including a relationship in which the refractive index ns of the active layer is highest, and a refractive index na of the n-type cladding layer is higher than a refractive index nb of the p-type cladding layer:

$ns > n1 > n2 > n3 >, \ldots, nN > na > nb,$

a refractive index difference between mutually adjacent layers among said plurality of layers which compose the first SCH layer and second SCH layer is set to be smaller as going further from the active layer in a relationship of:

$ns-n1 > n1-n2 > n2-n3 >, \ldots, > nN-nb > nN-na,$ and

a relationship of the thicknesses of the layers is set in the following relation so as to be larger as being more remote from the active layer:

$t1 < t2 < t3 <, \ldots, < tN.$

9. The semiconductor laser according to claim 5, characterized in that

assuming that a refractive index of a layer having the lowest refractive index among the layers forming

the active layer is ns;

that a refractive index and thickness of said plurality of layers in the first SCH layer are n1, n2, n3, ..., nN and t1, t2, t3, ..., tN, respectively, sequentially from a side closer to the active layer; and

that a refractive index and thickness of said plurality of layers in the second SCH layer are n1, n2, n3, ..., nN and t1, t2, t3, ..., tN, respectively, sequentially from the side closer to the active layer,

a relationship of the thicknesses of the layers is set to be equal to each other in a relationship of:

$t1 = t2 = t3 =, \ldots, = tN$,

a great and small relationship of the refractive indexes of the layers is set so as to be smaller as going further from the active layer as shown below, including a relationship in which the refractive index ns of the active layer is highest, and a refractive index na of the n-type cladding layer is higher than a refractive index nb of the p-type cladding layer:

$ns > n1 > n2 > n3 >, \ldots, nN > nb$, and also

$na > nN$, and

a refractive index difference between mutually adjacent layers among said plurality of layers which compose the first SCH layer and second SCH layer is set to be smaller as going from the active layer to the n-type cladding layer and the p-type cladding layer in

a relationship of:

$ns-n1 > n1-n2 > n2-n3 >, \ldots, > n(N-1)-nN.$

10. The semiconductor laser according to claim 5, characterized in that

assuming that a refractive index of a layer having the lowest refractive index among the layers forming the active layer is ns;

that a refractive index and thickness of said plurality of layers in the first SCH layer are n1, n2, n3, ..., nN and t1, t2, t3, ..., tN, respectively, sequentially from a side closer to the active layer; and

that a refractive index and thickness of said plurality of layers in the second SCH layer are n1, n2, n3, ..., nN and t1, t2, t3, ..., tN, respectively, sequentially from the side closer to the active layer,

a great and small relationship of the refractive indexes of the layers is set so as to be smaller as going further from the active layer as shown below, including a relationship in which the refractive index ns of the active layer is highest, and a refractive index na of the n-type cladding layer is higher than a refractive index nb of the p-type cladding layer:

$ns > n1 > n2 > n3 >, \ldots, nN > nb$, and also

$na > nN$,

a refractive index difference between mutually adjacent layers among said plurality of layers which

compose the first SCH layer and second SCH layer is set to be in a relation of:

$ns-n1 = n1-n2 = n2-n3 =, \ldots, = nN-nb$, and

relationship of the thicknesses of the layers is set to be larger as being more remote from the active layer in a relation of:

$t1 < t2 < t3 <, \ldots, < tN$.

11. The semiconductor laser according to claim 5, characterized in that

assuming that a refractive index of a layer having the lowest refractive index among the layers forming the active layer is ns;

that a refractive index and thickness of said plurality of layers in the first SCH layer are n1, n2, n3, ..., nN and t1, t2, t3, ..., tN, respectively, sequentially from a side closer to the active layer; and

that a refractive index and thickness of said plurality of layers in the second SCH layer are n1, n2, n3, ..., nN and t1, t2, t3, ..., tN, respectively, sequentially from the side closer to the active layer,

a great and small relationship of the refractive indexes of the layers is set so as to be smaller as going further from the active layer as shown below, including a relationship in which the refractive index ns of the active layer is highest, and a refractive index na of the n-type cladding layer is higher than

a refractive index nb of the p-type cladding layer:

ns > n1 > n2 > n3 >, ..., nN > nb, and also

na > nN,

a refractive index difference between mutually adjacent layers among said plurality of layers which compose the first SCH layer and second SCH layer is set to be smaller as going further from the active layer in a relationship of:

ns-n1 > n1-n2 > n2-n3 >, ..., > n(N-1)-nN, and

a relationship of the thicknesses of the layers is set to be larger as being more remote from the active layer in a relationship of:

t1 < t2 < t3 <, ..., < tN.

12. The semiconductor laser according to claim 4, characterized in that the semiconductor laser is formed in a buried heterostructure.

13. The semiconductor laser according to claim 12, characterized in that

part of the n-type cladding layer, the first SCH layer, the active layer, the second SCH layer, and the p-type cladding layer is formed in a mesa shape, and

the semiconductor laser further comprises:

a first buried layer made of p-type InP, which is formed with one side thereof in contact with the semiconductor substrate or the n-type cladding layer at both sides of each layer formed in the mesa shape; and

a second buried layer made of n-type InP, which is

formed with one side thereof in contact with the p-type cladding layer and the other side thereof in contact with the other side of the first buried layer at both sides of each layer formed in the mesa shape.

14. The semiconductor laser according to claim 1, characterized in that the semiconductor laser is formed in a ridge structure.

15. The semiconductor laser according to claim 14, characterized in that, when the semiconductor substrate is an n-type, the p-type cladding layer is formed as a ridge structure portion with substantially the center of the outside being raised to the upside, and

the semiconductor laser further comprises:

a contact layer formed on a upside of the ridge structure portion in the p-type cladding layer;

an insulating layer having an opening portion above a center of the contact layer and which is formed to cover the p-type cladding layer including the ridge structure portion; and

an electrode formed on a top of the insulating layer with a part thereof connected to the contact layer.

16. The semiconductor laser according to claim 1, characterized in that a bandgap wavelength of InGaAsP which composes the n-type cladding layer is a bandgap wavelength of InP or more and 0.98 μm or less.

17. The semiconductor laser according to claim 16, characterized in that a bandgap wavelength of InGaAsP which composes the n-type cladding layer is 0.96 μm or more and 0.98 μm or less.

18. The semiconductor laser according to claim 1, characterized in that, when the semiconductor substrate is an n-type, the n-type cladding layer is formed beneath the active layer, and the p-type cladding layer is formed above the active layer.

19. The semiconductor laser according to claim 1, characterized in that, when the semiconductor substrate is a p-type, the n-type cladding layer is formed above the active layer, and the p-type cladding layer is formed beneath the active layer.